Statisticalstudy of the vegetative aerial architecture of three Tunisians date palm cultivars

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SUMMARY

The date palm (*Phoenix dactylifera* L.)is the main element upon which the sustainable biophysical and socio-economic organizations of the oasis ecosystem are based. The present study was carried to verify the statistical relationships between the characteristic parameters in terms of vegetative aerial architecture of the date palm. The vegetal material was composed of three Tunisians varieties of *Phoenix dactylifera* L., 'Barhi', 'Rochdi' and 'Kenta'. The observations are taken place in Gabes and on one pair of palms per main stem and offshoot for each cultivar. The analysis of the characteristic dimensions of the pinnae and nervure allowed the determination of a minimum sample. The geometrical analysis confirmed the existence of a significant correlation between rotation angles and radial angles.

Keywords: Architecture, correlation, minimum sample, *Phoenix dactylifera* L.

RESUME

Le palmier dattier(*Phoenix dactyliferaL.*) est l'élément principals ur lequel les organisations biophysiques et socio-économique durable de l'écosystème oasien sont fondées. La présente étude a été réaliséeafin de vérifier les relations statistiques entreles paramètres caractéristiques en termes d'architecture aérienne végétative du palmier dattier. Le matériel végétal est composé de trois cultivars Tunisiens de *Phoenix dactylifera* L., 'Barhi', 'Rochdi' et 'Kenta'. Les observations ont été réalisées à Gabès et sur une paire de palmes par pied mère et son rejet pour chaque cultivar. L'analyse des dimensions caractéristiques des pennesetnervure a permis la détermination d'un échantillon minimal. L'analyse géométrique a confirmé l'existence d'une corrélation significative entre lesangles de rotationet angles radiaux.

Mots-clés:architecture, la corrélation, l'échantillonminimum, Phoenix dactyliferaL.

1. INTRODUCTION

Plant architecture is defined like the whole of the structural forms which the plant presents through its existence; topology is the way in which its organs are laid out the ones linked to the others, while the geometry describes the size and arrangement in the space of these organs (Barthelemy and Caraglio). Date palm, *Phoenix dactylifera* L. (*Arecaceae*), is a dioecious monocotyledon; its vegetative propagation through shoot cuttings is widely practiced. Belonging to the *Phoeniceae* tribe Uhl and Dransfield (1987) classified in the model of corner according to the botanist Halle et Oldeman (1970), the date palm is built with one vegetative axis with apical continues growth and a massive crown of leaves with thorny base, the inflorescence are produced laterally to the palm leaves. In the context of the present study, we focus ourselves on the architectures and the geometry of the palms of this species.

Several paper have dealt with architecture in *Arecaceae,* The first measurement of palm date architecture has been done by Dolle in 1989 and later by El Houmaizi in 2002. MOCAF *Phoenix* network, which is an Euromediterranean project, cafrries out studies on date palm but always remaining bounded to the other palm trees researches.

2. MATERIALS AND METHODS

The vegetal material was composed of three Tunisian cultivars: 'Barhi', 'Rochdi' and 'Kenta'. The measured palms were taken in the palm groves of Gabes in Tunisia. Observations were conducted on one pair of palms per main stem and offshoot for each variety. Studying the palm tree architecture needs the measerments of various metric and geometrical parameters .Metric measurement related to the nervure characteristics including the nervure length from the insertion on the stem to the extremity, widths and height taken every 10 cm and length of the spiny and pinnate parts measured with one tape meter.

Metric characteristics of the pinnae throughout the nervure counting pinnae length ,pinnae opening at the first and second third of their length , pinnae width at the base,the first and the second third of their length,they were measered by means of digital caliper.

Geometrical characteristics of the pinnae ,these parameters are three main insertion angles of pinnae relative to the nervure diections: Axial angle is the angle between the main directions of the pinnae and the nervure, radial angle is the orthogonal projection of the angle between the main direction of the pinnae and the line joining right and left insertion points on the nervure and rotation angle is the angle between the insertion scare and a perpendicular to the main direction of the nervure.

The sample size of the metric characteristics of the nervure and the pinnae will be estimated using techniques issued from the regionalized variables theory. Considering Da and Db are the random variables recorded on frond A and frond B of the studied palm tree.According to Aubry in 2000 (Richardson et Hémon-1981, Clifford et Richardson-1985 et Clifford et al.-1989), respecting the hypothesis of spatially homogeneous variances and covariances, the co-variance between Da and Db may be estimated using the following classical estimators:

$$\hat{C}Da\ (h) = 1/N(h) * \sum_{i,j|h_{ij}=h} (Dai - Mean\ (Da)) * (Daj - Mean\ (Da))$$

$$\hat{C}Db(h) = 1/N(h) * \sum_{i,j|h_{ij}=h} (Dbi - Mean(Db)) * (Dbj - Mean(Dd))$$

The variance of r (б$r^{2)}$ may be the estimated by:

$$бr^2 = [\Sigma\ N(h)* \hat{C}LDa(h)*\hat{C}Db(h)]/[n^2* Mean(Da)^2* Mean(Db)^2]$$

Where n is the number of paired measurement and N (h) is the number of couple of measurements for given h distance on the non oriented axe. The minimum useful sample size is the defined as to be m= 1 – бr^2 . If the 2 variables are positively auto-correlated, then m<n. If they are not m = n.If they are negatively auto-correlated, it can be expected that m > n.

3. RESULTS

3.1. Width and height of nervure sections

The position on the nervure is normalized relatively to the total length of nervure. Width and height are normalized relatively to their maximum value. Figures 1, 2, and 3 show the dot groups for the measurements taken every 10 cm on the nervure of the fronds. The width and height data noted for the two cultivars showed that the width and height of the nervure are strongly dependent of their position on the nervure.

The ratio data height/Width of nervure sections noted for the three cultivars figures 4, 5 and 6 varied between 0.5 and 2.5 along the nervure. As the variable width of nervure is strongly regionalized, the Aubry's method can be used for estimating the minimum sample table 1.It gives a sample size of 4 sections along the nervure for the two cultivars 'kenta' and 'Rochdi' and of 3 sections for the variety 'Barhi'.

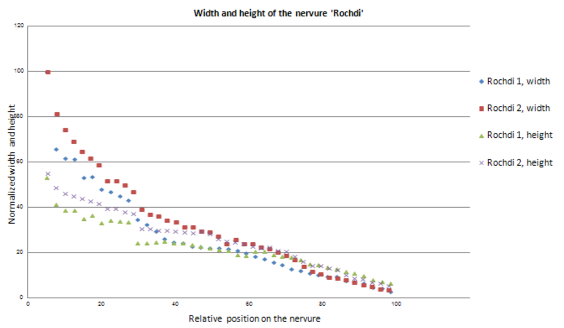

Figure 1 : Width and height 'Rochdi'

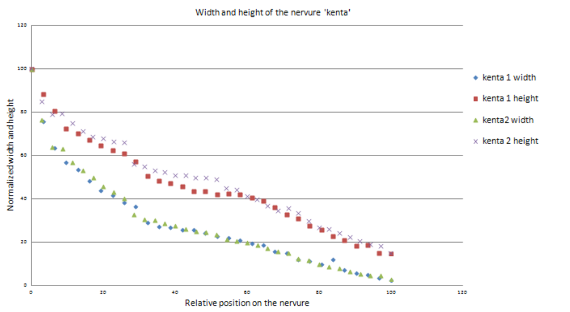

Figure 2 : Width and height 'Kenta'

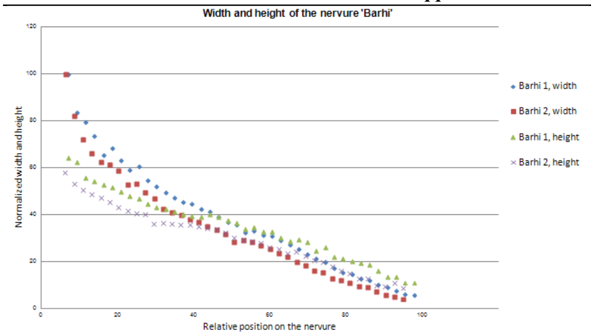

Figure 3 : Width and height - Rochdi

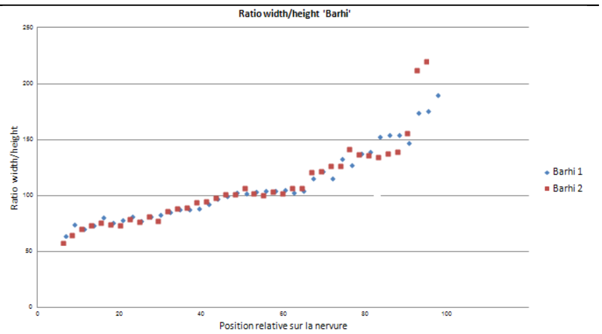

Figure 4: Ratio height/Width of nervure sections 'Barhi'

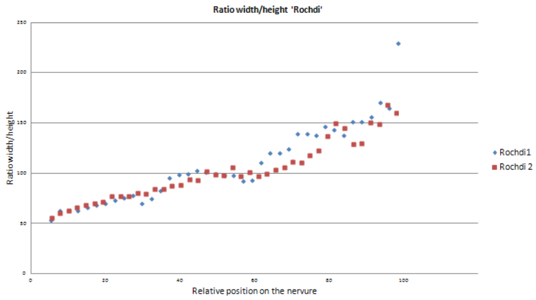

Figure 5: Ratio height/Width of nervure sections 'Rochdi'

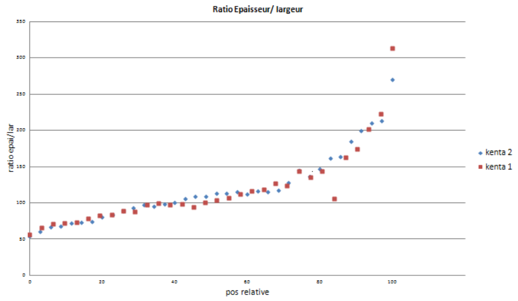

Figure 6: Ratio height/Width of nervure sections 'kenta'

3.2. Length of pinnae

The position on the nervure is normalized relatively to the total length of nervure and the pinnae length is normalized relatively to it is maximum value measured on left or right side of the frond .For each studied palm tree figures 7, 8 and 9 show the evolution of the dot groups for the length measurements of all pinnae located on one or the other sides of each frond. It seems that the length of the pinnae is strongly related to its position along the nervure. The three figures show an acceleration of the size difference between the pinnae at the time of transition between spines and leaflets. This phenomenon should not be regarded as discontinuity but as acceleration.

As the variable length of pinnae is strongly regionalized, the Aubry's method can be used for estimating the minimum useful sample table 2.It gives a sample size ranging between 5and 6 for the three cultivars.

3.3. Width of pinnae at the first third of its length

The position on the nervure is normalized relatively to the total length of nervure and the pinnae width is normalized relatively to it is maximum value figures 10, 11 and 12 showed that the width of the pinnae is strongly dependent of its position on the nervure. The Aubry's method can be used for estimating the minimum sample table 3.It gives a sample size ranging between 4 and 7 for the three studied cultivars.

3.4. Relation between rotation angle and radial angle of pinnae

Figures 13, 14 and 15 show for the three cultivars the dot groups and the linear regression including its equation and signification coefficient.Barhi R^2=0.37 'Rochdi' R^2=0.39 and 'kenta' R^2= 0.45.This result confirms the significant correlation between rotation angle and radial angle of pinnae.

Table 1. Estimation of utile minimum sample size for nervure section width estimations.

	Rochdi	Barhi	Kenta
Variance de r (x,y)	0.5	0.6	0.3
Utile min sample	3	3.7	3.5

Table 2. Details of the estimation of utile minimum sample size for pinnae length estimation

	Rochdi	Barhi	kenta
Variance de r (x,y)	0.21	0.25	0.15
Utile min sample	5.7	4.9	4.37

Table 3. Details of the estimation of utile minimum sample size for pinnae width estimation

	Barhi 1	Barhi 2	Rochdi 1	Rochdi 2	Kenta 1	Kenta 2
Variance de r (x,y)	0.31	0.32	0.3	0.17	0.33	0.33
Utile min sample	4.2	4.1	4.3	6.6	3.97	4.02

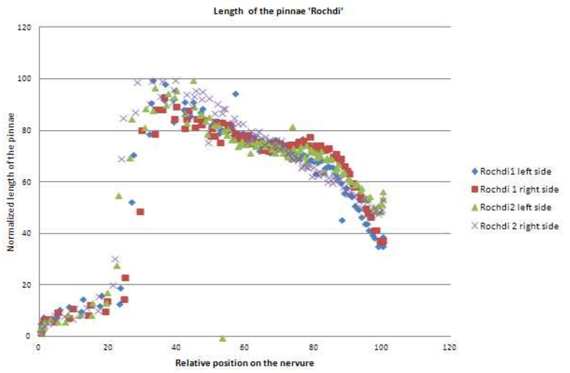

Figure 7 : Length of pinnae- 'Rochdi'

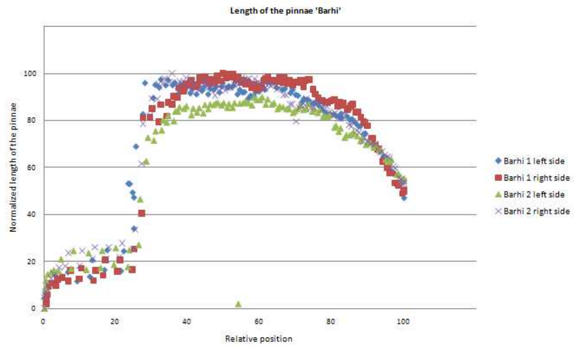

Figure 8 :Length of pinnae- 'Barhi'

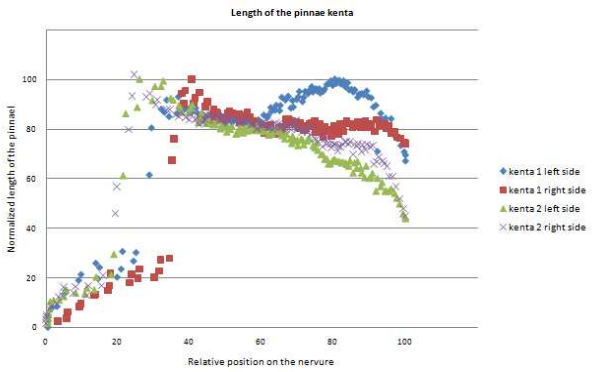

Figure 9 : Length of pinnae- 'kenta'

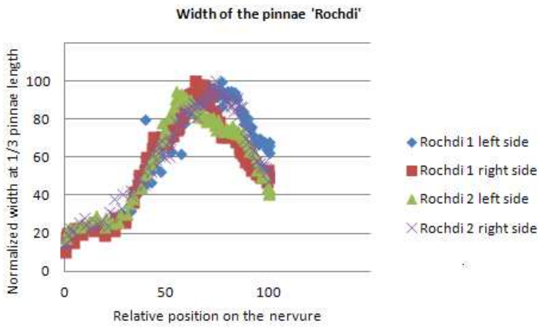

Figure 10 :Width of pinnae at 1/3 of their lengths-'Rochdi'

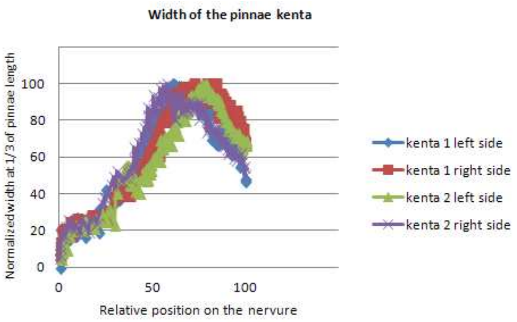

Figure 11 : Width of pinnae at 1/3 of their lengths-'kenta'

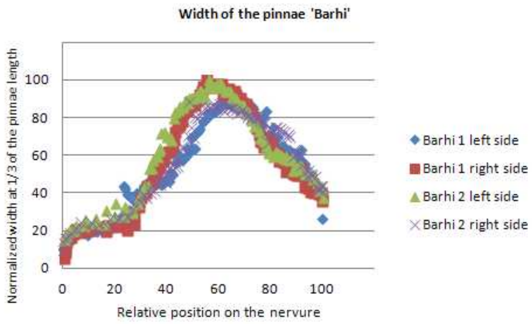

Figure 12 : Width of pinnae at 1/3 of their lengths-'Barhi'

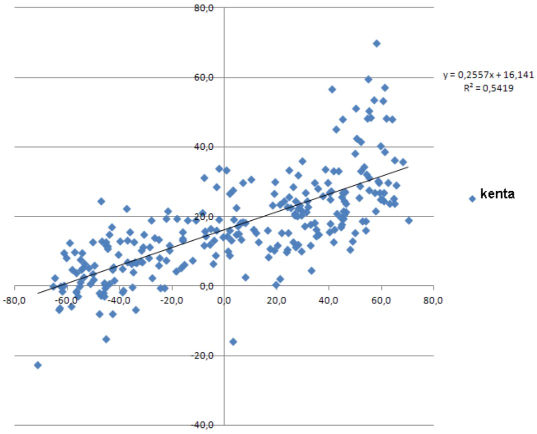

Figure 13 :Radial angle f(Rotation angle) 'kenta'

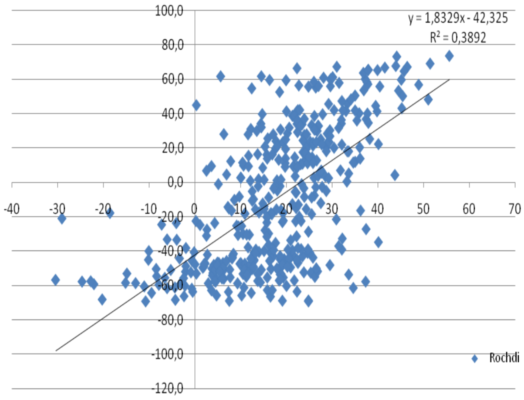

Figure 14 : Radial angle f(Rotation angle) 'Rochdi'

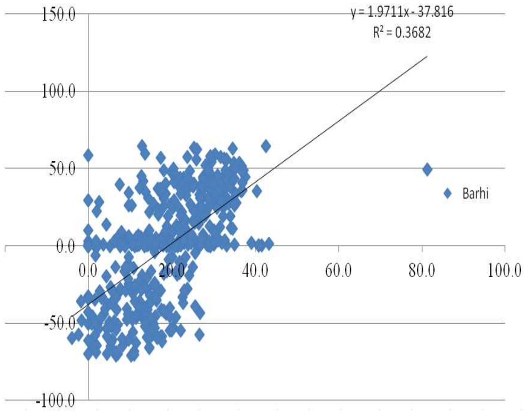

Figure 15 : Radial angle f(Rotation angle) 'Barhi'

4. DISCUSSION

Our results confirms the results obtained by El Houmaizi (2002), Memadji-Le Allah (2011) and Lecoustre and al. (2011).Our results showed that the width and the height of nervure section are strongly dependent on their position on the nervure.The ratio height on width for nervure sections throughout the nervure is regular according to Lecoustre it appears adjustable to a statistical function curve whose type remains to be discovered according to knowledge in biomechanics.The modeling of the relationship between width and height of the nevure indexed on the position throught this nervure may allow us to reduce the observation to only one of the two metric parameters and so shorten the observation time.El Houmaizi reported that width variation throughout the nervure is adjustable to an exponential function, knowing that the coefficient is strongly dependent of the palm length,the normalization gives the following equation: $Y=1,\ 2482\ x^{-1,\ 3648}$ with $R^2=0,\ 9663$.Our results demonstrate that the length of the pinnae is strongly dependent of its position on the nervure and seems to be a pointer of the cultivar.The geometrical measurement confirms the significant correlation between rotation angle and radial angle of pinnae for the three cultivars 'Barhi','kenta' and 'Rochdi' it's the same result obtained with the Italian morphotypes 'Romana' and 'Ebrea' so we can reduce the observation to only one of the two angles. According to Lecoustre it exist also a strong correlation between axial and rotation angle and the calculation adjustement obtained by gathering datas of the Italian morphotypes and Tunisian cultivars, linear regression gives the following equation:Y= 0,2642 x+ 20,627 with R^2=0,57.As it easier to mesure the rotation angle we can estimate axial angle from the rotation angle linear regression formula.

5. CONCLUSION

Our study showed that the metric characteristic of the nervure and the pinnae are strongly dependent of their position throughout the nervure and can be considered as regionalized variables.This result allowed us to estimate a useful sample size for the nervure and pinnae parameters. It can also used for reducing the number of studied parameters and shorten the observation time and protocol. The strong correlation between radial and rotation angle allows us to reduce the measurement to only one of the

two angles. All these characteristics are used as a taxonomical index to differentiate between the three Tunisian varieties.
We envision the next step will be the study of the architecture and geometry of the date palm inflorescence.

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